"Autonomous Radiation Monitoring and Surveillance Robot for hazardous environment"

Project Members

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Contents

Problem Statement

Nowadays radiation isotopes has been widely used in various application centres such as Nuclear Power plants, Isotopes manufacturing factories like urea, Radiation treatments etc. Such radiation may cause various cancers if it is unnoticed, and also these radiations may affect the environment which may cause unsuitable environment for the people those who are in and around such environments. In order to monitor such radiation there is a need for monitoring device to continuously monitor such radiations and provide good environment for the workers those who are working in such environments and safety measures for such people.

ABSTRACT

In 21rst century Nuclear energy has emerged as one of the most reliable sources of energy. But like any other energy source it comes with its own disadvantages, one of which is the life threatening working conditions. The radiations in these plants emitted because of radiation isotopes cause many fatal diseases including cancer when users/workers working in these environments are exposed to it. In our project we intend to build an autonomous radiation monitoring and surveillance robot operable with MyRio for hazardous environment. So, with this project we intend to make a surveillance system which would help to take the precautionary measures at right time. Such measure data are transferred to remote system for monitoring the radiation and ensuring the safety of the users/workers those who are working in such hazardous environment like nuclear power plant etc. Further we involve GPS module along with MyRio to locate the leakage of high radiation location

Novelty

With the advent of nuclear power and radioactive research, it has become necessary to remote monitor the hazardous environments on timely basis. Our project is an autonomous radiation cum surveillance and monitoring robot which proves to be cheap and robust. It can be deployed in any radio isotopes radiation environment to monitor the radiations and do surveillance both in manual and automatic. Furthermore our system includes GPS to remote monitor the location of high radiations and also includes alarming system to alert the people those who are working in hazardous nuclear and/or radio isotope environment.

Literature Review

Radioactive sources are used in various applications and such sources leading to hazardous work environment for the human kind causing side effects leading to various cancer related diseases. An autonomous mobile robot for nuclear power plants is described in [1] which includes a localization systems based on pattern matching which involves laser rangefinder for mapping the environment. In order to cover long range data the authors [2] has proposed an APRS protocol to send the radiation measuring of GM system so that automatic remote monitoring of the system is carried out. Further to monitor the radiation with better Graphical User Interface, the author [3] has used LabVIEW along with GM Counter and Data acquisition hardware interface to monitor the radiation data. The distributed network system as discussed in [4] is combined with gamma counts so as to increase the SNR along with the increase in the number of detectors used as arrays. Further, development in the wireless sensor networks there is rapid growth in detection of radiations along with a system to keep tracking the moving radioactive source. Such tracking may result in statistical analysis of performance related to efficiency and false detection in the distributed network [4]. There are many more detectors are available in detecting the man-made radiations sources such as Cs, Mn, Co-58, Co-60, Ir-192. One such detector is the Portable environmental radiation monitoring system [5] that is used to measure the exposure-dose rate at environmental levels. Such system [5] is useful to measure the radiation in the environment but there is no early warning and alert system is provided for any radioactive leakage in the radiation therapy room, industrial, nuclear power plant etc. To safe guard the humankind from such radiation leakage an early warning and alert system is incorporated in the system [6] to detect the radiation leakage and providing early warning and altering to the people or users working in that particular environment so as to safeguard the people from external exposure of radiations.

Radiation Sources

Radiations are constantly present in the atmosphere, and every single human being, plant and animal are being exposed to it continuously. Even human bodies emit some measure of radiation. There are two types of radiations namely ionizing radiation and non-ionizing radiation. Ionizing radiation causes disintegration of cells in an element. Ionizing radiations can be a wave or a particle. Non-ionizing radiation are electromagnetic waves which do not cause any disintegration. Non ionizing radiations subsist only in wave phenomena. These radiations are not harmful to us since their intensity level is below the hazardous level. Ionizing radiation has two major types of radiation sources, natural background sources and man-made sources. Further various radioactive isotopes with corresponding applications are listed in the Table. 1

Table 1

Radioactive Isotope	**Industrial Applications**
Americium-241	Gives constant thickness when steel and paper are rolled; detect where oil wells are present
Sodium-24	Uncover leaks in pipe lines
Iridium-192	Evaluate strength of aircraft components
Uranium-235	Fuel for power plants, manufacture of luminous glass and stained tiles
Californium-252	Construction of pavement and buildings

Artificial Background Radiation:

- **Medical:**

Human exposure to artificial radiation is principally from medical devices like diagnostic X-rays. Other man made sources consist of smoking, flying, and nuclear accidents. Radiation treatment like radiation therapy, Magnetic Resonance Imaging (MRI) scan also contributes to some dosage, both in patients and workers. Radiation used in healthcare fields is the largest source of radiation that people are exposed to.

Most of this exposure is from diagnostic X-rays, used by healthcare officials to detect the degree of sickness or corporeal damage. In nuclear medicine, radiopharmaceuticals are helpful during diagnosis and treatment, while radiation therapy is needed for cancer treatment and tumor removal and has the highest dose of radiation.

- **Occupational Exposure:**

Radiation consumed by the human body causes the human cell deficiencies that may elevate the danger of disease and hereditary impact. It is in this manner imperative for laborers to restrain their exposure to radiation in their work environments. Industries where radiation is regularly used, especially nuclear power plants, have a record where the radiation dose each laborer is exposed to in a day or in a week is noted down. The commonly used radioactive isotopes and their industrial applications are shown in Table 1. In hospitals the cancer and tumors treatment are carried out using radiation therapy, the physicians who work in those rooms also has a record that shows how much radiation they are exposed to radioactive isotope used in hospital are listed in below Table.2

Table 2

Radioactive Isotopes	**Medicinal Applications**
Cobalt-60	Radiotherapy for treating cancer
Iodine-131	Detect brain tumors, for cardiac and thyroid treatment
Carbon-14	Observe metabolism transition in diabetes patients
Carbon-11	In PET scans to ensure that organs are working properly
Sodium-24	Observe circulation of blood
Thallium-201	Detect impairment in blood tissue

References discussed in Literature Review:

1. Etsurou Igarashi, Katushiko Sato “Hierarchical Autonomous Mobile Control systems of a Patrol Robot for Nuclear Power Plants” , Robotics and Automation, 1995. Proceedings., 1995 IEEE International Conference on 06 August 2002.

2. Sawatsakom Chaiyasoonthom ,Nimit Hongyim, and Somsak Mitatha,” Building Automatic Packet Report System to report position and radiation data for autonomous robot in the disaster area” , 15th International Conference on Control, Automation and Systems (ICCAS 2015), Oct. 13-16, 2015 in BEXCO, Busan, Korea.

3. Masudul Hassan Quraishi, Md. Aminul Hoque, Anisa Begu, Mohammad Jahangir Alam, “Computer Based Radioactivity Measurement with Acquisition and Monitoring Radiation Data Using LabVIEW”, 3rd INTERNATIONAL CONFERENCE ON INFORMATICS, ELECTRONICS & VISION 2014.

4. R. J. Nemzek, J. S. Dreicer and D. C. Torney, "Distributed sensor networks for detection of mobile radioactive sources," 2003 IEEE Nuclear Science Symposium. Conference Record (IEEE Cat. No.03CH37515), 2003, pp. 1463-1467 Vol.3.

5. D. L. Stephens and A. J. Peurrung, "Detection of moving radioactive sources using sensor networks," in IEEE Transactions on Nuclear Science, vol. 51, no. 5, pp. 2273-2278, Oct. 2004.

6. S. M. Brennan, A. M. Mielke, D. C. Torney and A. B. Maccabe, "Radiation detection with distributed sensor networks," in Computer, vol. 37, no. 8, pp. 57-59, Aug. 2004.

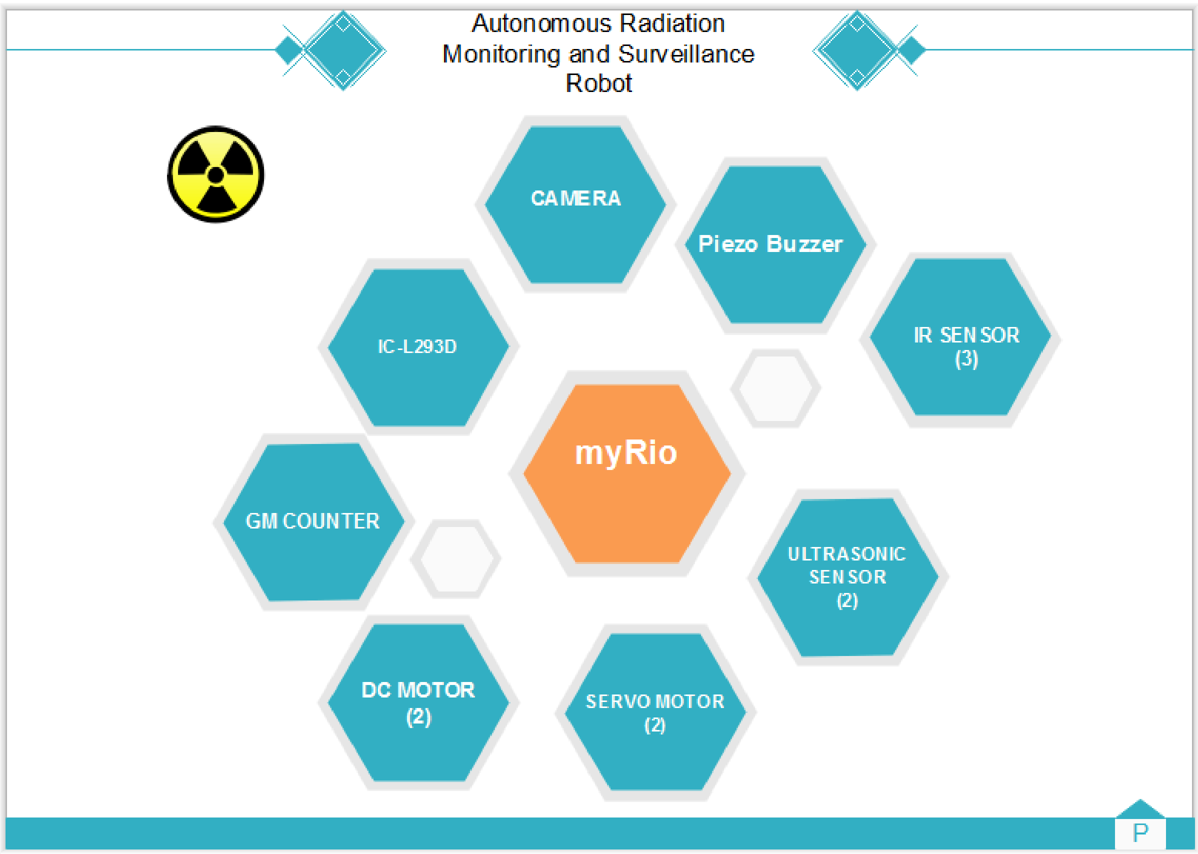
Systems Engineering Approach

Our autonomous mobile robot includes an automated robotic system with remote radiation monitoring unit which comprises of MyRio with GM counter to continuously monitor the radiation in radio isotopes environment. Further the robotic system also includes surveillance monitoring unit to remotely surveillance the radiation indoor environment and remotely transfer the captured data to web server. This surveillance monitoring unit comprises USB web camera interfaced to “MyRio” to remote survelliance and detects humans in such hazardous environment. The camera is integrated to pan tilt arrangement which consists of two servo motors to rotate the mounted camera to different angles for surveillance purpose. The servo motors are interfaced to MyRio and the pan tilt to get better and accurate coverage of the area and the pan tilt directions are controlled using PWM configured with MyRio.

The robotic system also includes obstacle avoidance to detect any obstacle and continue in its own path. In order to follow the path the robot is implemented with IR sensors which might act as line detector. Sensors such as the infrared sensors are being used for line follower whereas the ultrasonic sensor is the key to obstacle avoidance. The mobile robot will be made to move through a line follower through IR line detection. The GM counter will give the radiation levels of isotopes, if the level goes beyond the safe value the robot will be triggered and the preinstalled siren will be turned on which would alarm the workers. All this data will be fed back to laptop directly which would be the remote radiation display unit and this could help to take radiation safety precautionary measures for users/workers and thereby safety would be ensured. Finally the robotic system includes a GPS to locate the radiation location and remotely transfer the GPS data to the web server.

The sbove system approach is explained in the following section "System Involved with Hardware and Software Module"

Overall System Block Diagram



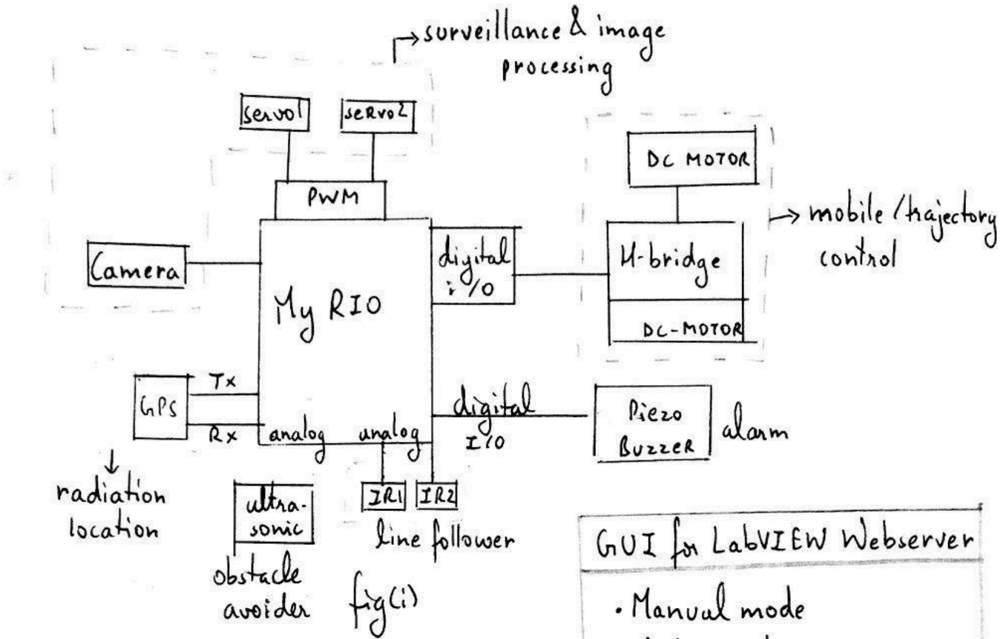
Programmatic Risks & Mitigation

Risk	Description	Impact	Probability of Occurence	Mitigation
Financial Constraints	Being a group of students we weren't able to add all the components as per our wish due to the same, e.g thermal camera	Major	High	We settled with components that were affordable and available.
Testing Constraints	Unavailibility of MyRio	Major	High	-NA-
Unavailability of Components	For testing each sub system the required components weren't available.	Major	HIgh	-NA-

Systems Involved with Hardware and Software Module

System Architecture and sensor module integrated with Labview-MyRio

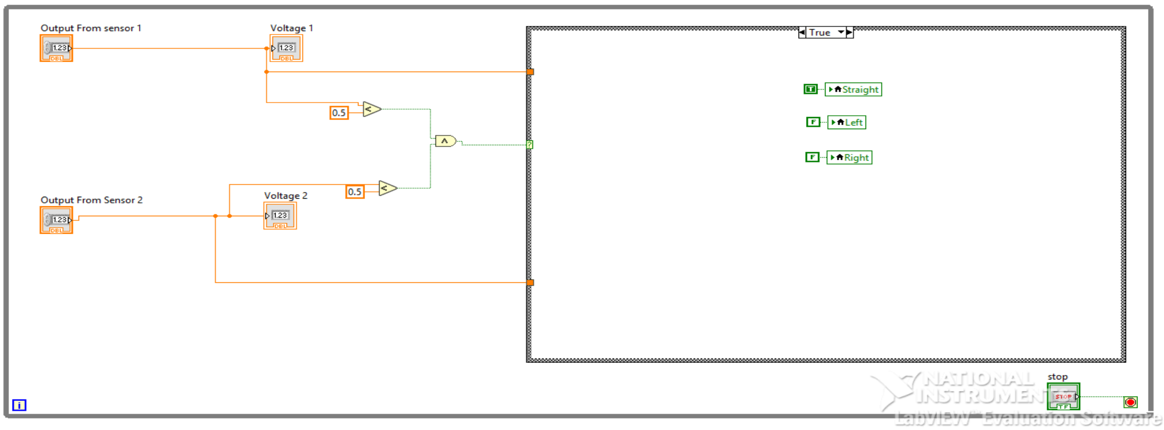
The following figure shows the various sensors interfaced to MyRio:

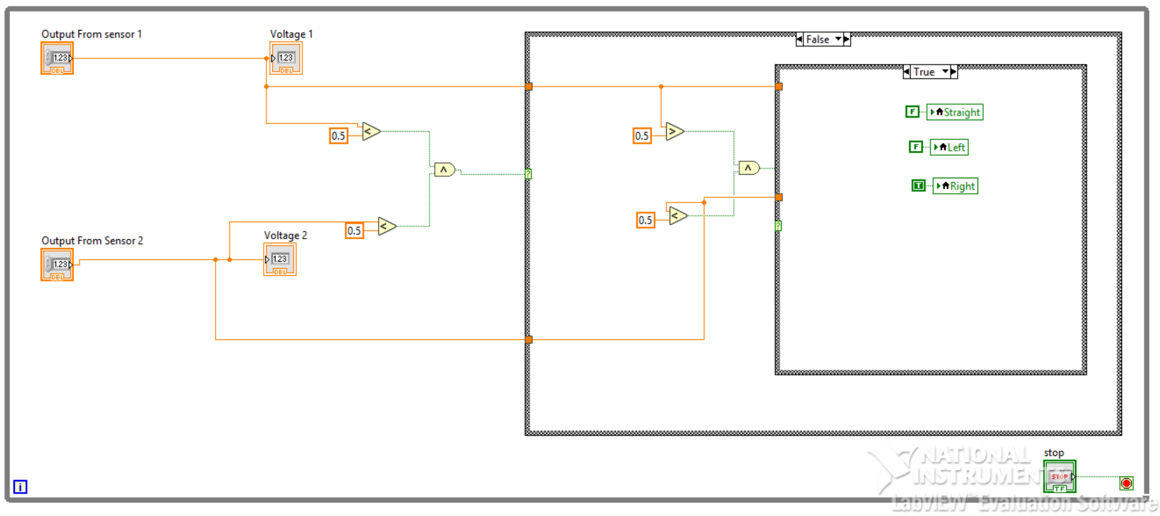


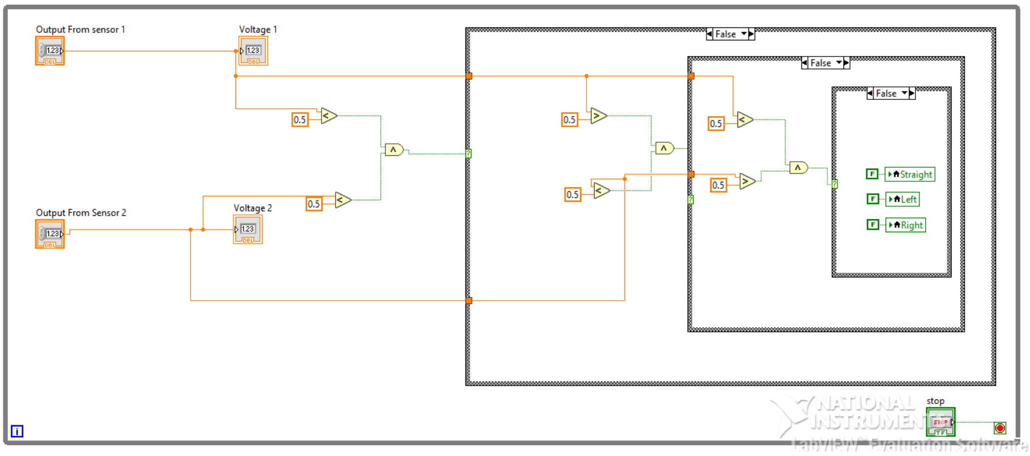
fig(i) System Architecture & Sensor Modules Integrated with LabVIEW MyRIO

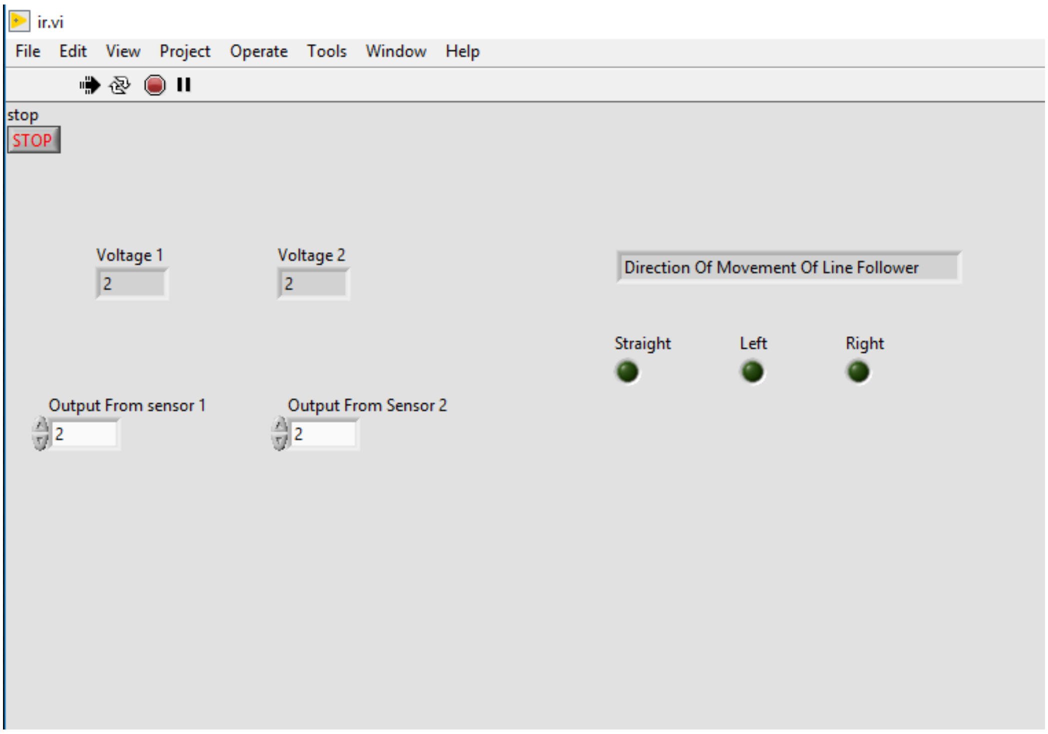
Line Follower

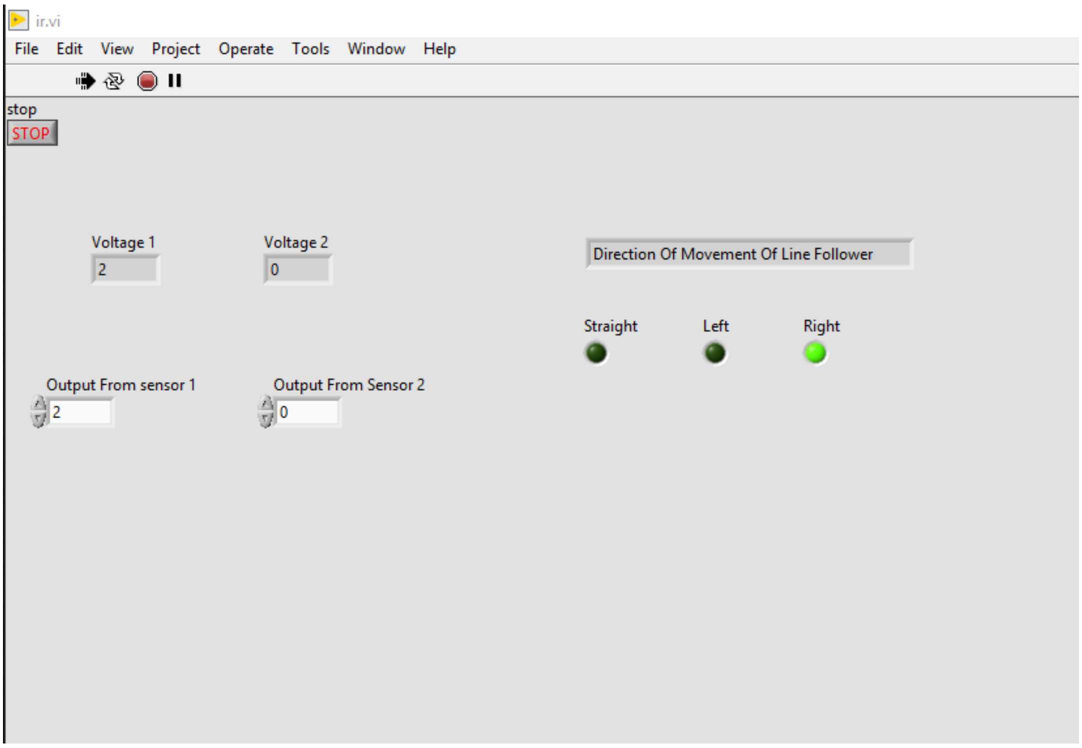
A system comprising of a pair of complementary infrared sensors and processor which make the device move on the guided path of either the black or the white line as these colours absorb or reflect most of the light respectively.

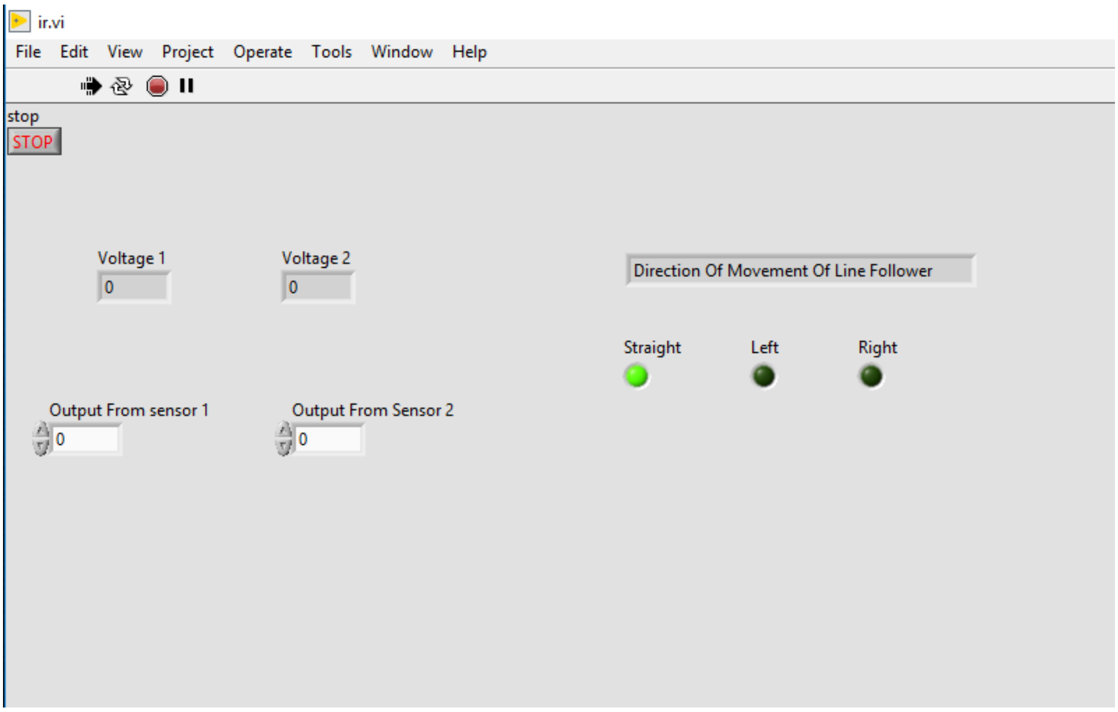

Output From sensor 1
Voltage 1
True
Straight
Left
Right
0.5
0.5
Output From Sensor 2
Voltage 2
stop
NATIONAL INSTRUMENTS
LabVIEW Evaluation Software

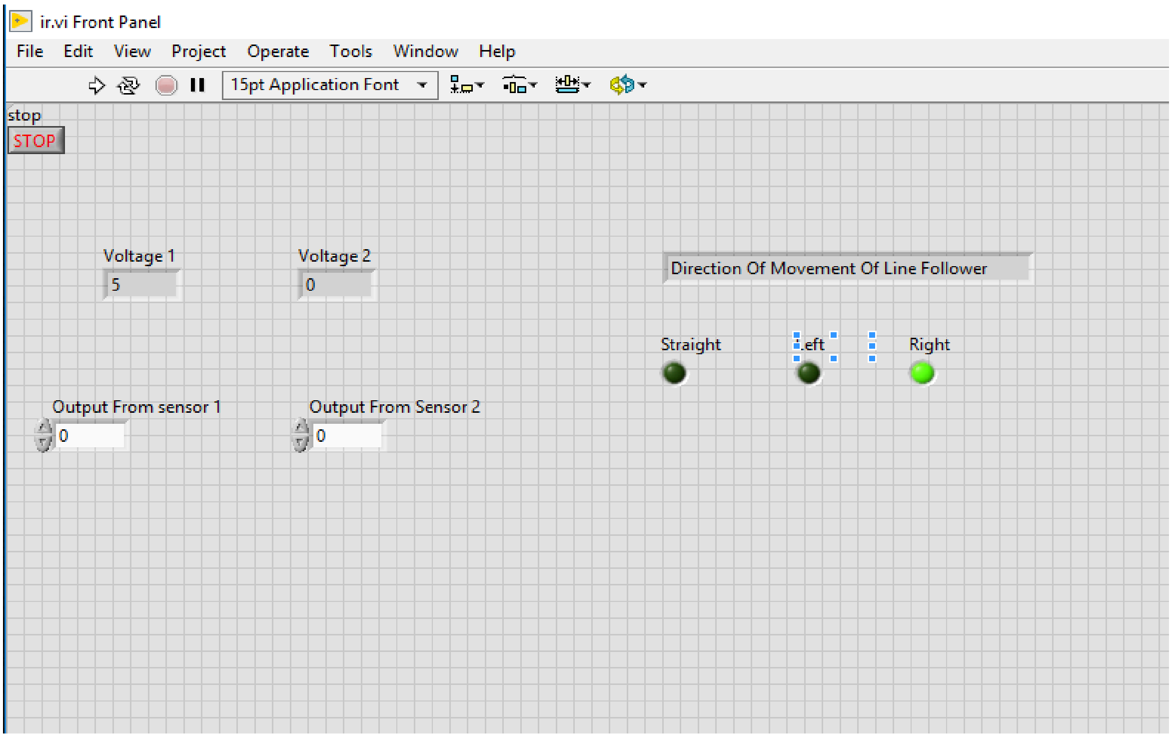

Output From sensor 1
Voltage 1
False
True
Straight
Left
Right
0.5
0.5
0.5
0.5
Output From Sensor 2
Voltage 2
stop
NATIONAL INSTRUMENTS
LabVIEW Evaluation Software

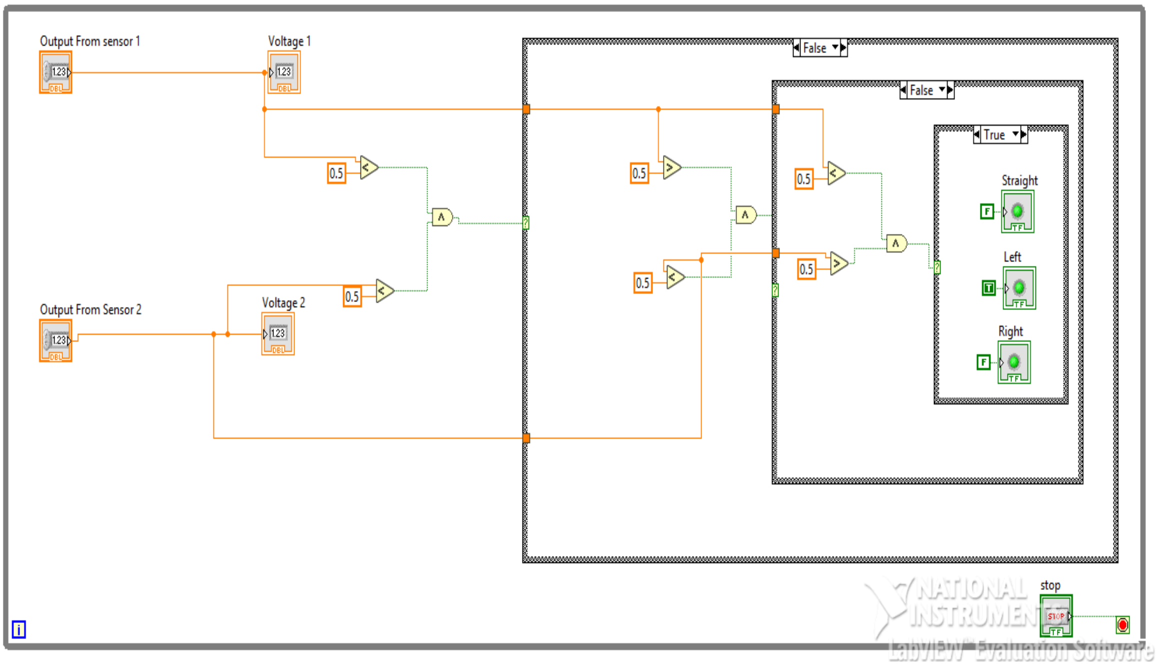

Output From sensor 1
Voltage 1
Output From Sensor 2
Voltage 2
0.5
False
Straight
Left
Right
stop

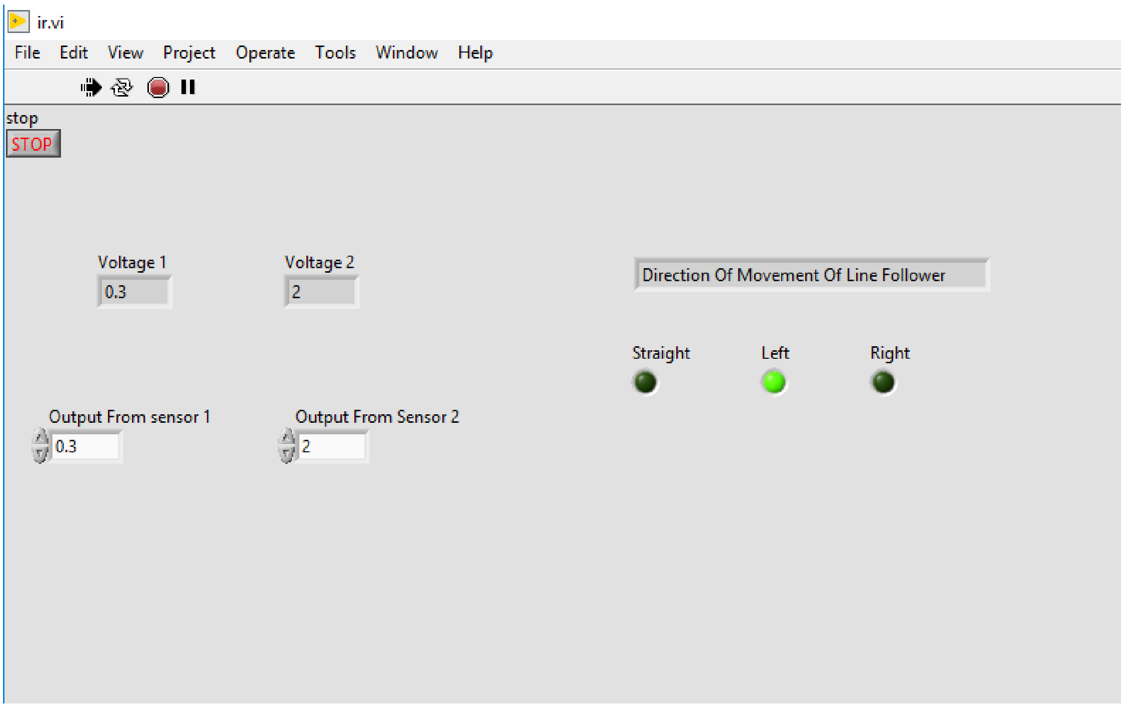

ir.vi
File Edit View Project Operate Tools Window Help
stop
STOP
Voltage 1
2
Voltage 2
2
Direction Of Movement Of Line Follower
Straight
Left
Right
Output From sensor 1
2
Output From Sensor 2
2


ir.vi
File Edit View Project Operate Tools Window Help
stop
STOP
Voltage 1
2
Voltage 2
0
Direction Of Movement Of Line Follower
Straight
Left
Right
Output From sensor 1
2
Output From Sensor 2
0

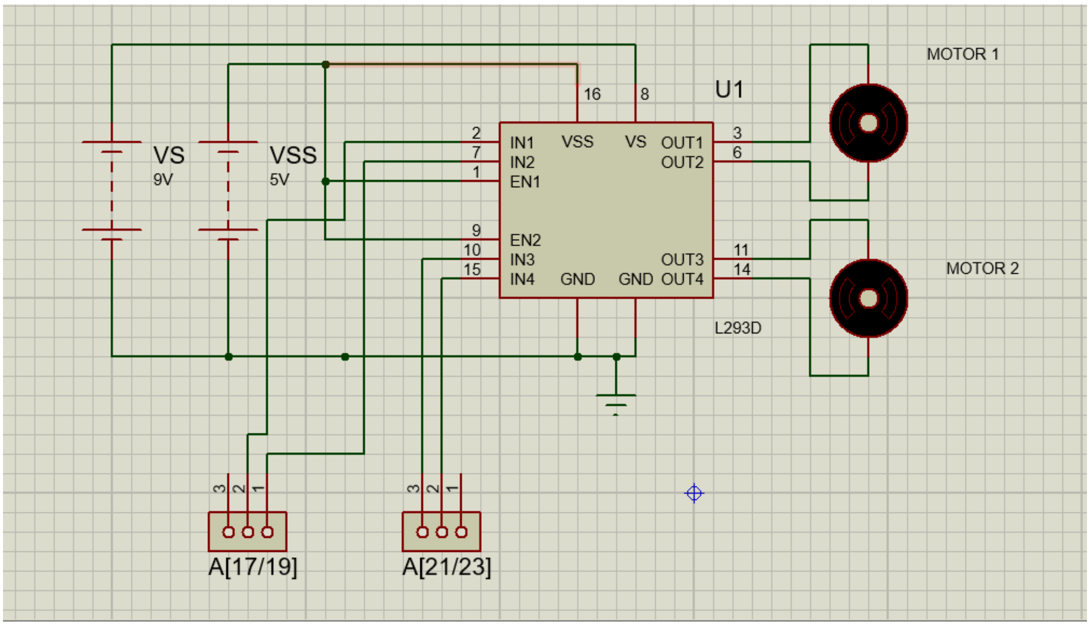

ir.vi
File Edit View Project Operate Tools Window Help
stop
STOP
Voltage 1
0
Voltage 2
0
Direction Of Movement Of Line Follower
Straight
Left
Right
Output From sensor 1
0
Output From Sensor 2
0


ir.vi Front Panel
File Edit View Project Operate Tools Window Help
15pt Application Font
stop
STOP
Voltage 1
5
Voltage 2
0
Direction Of Movement Of Line Follower
Straight
Left
Right
Output From sensor 1
0
Output From Sensor 2
0



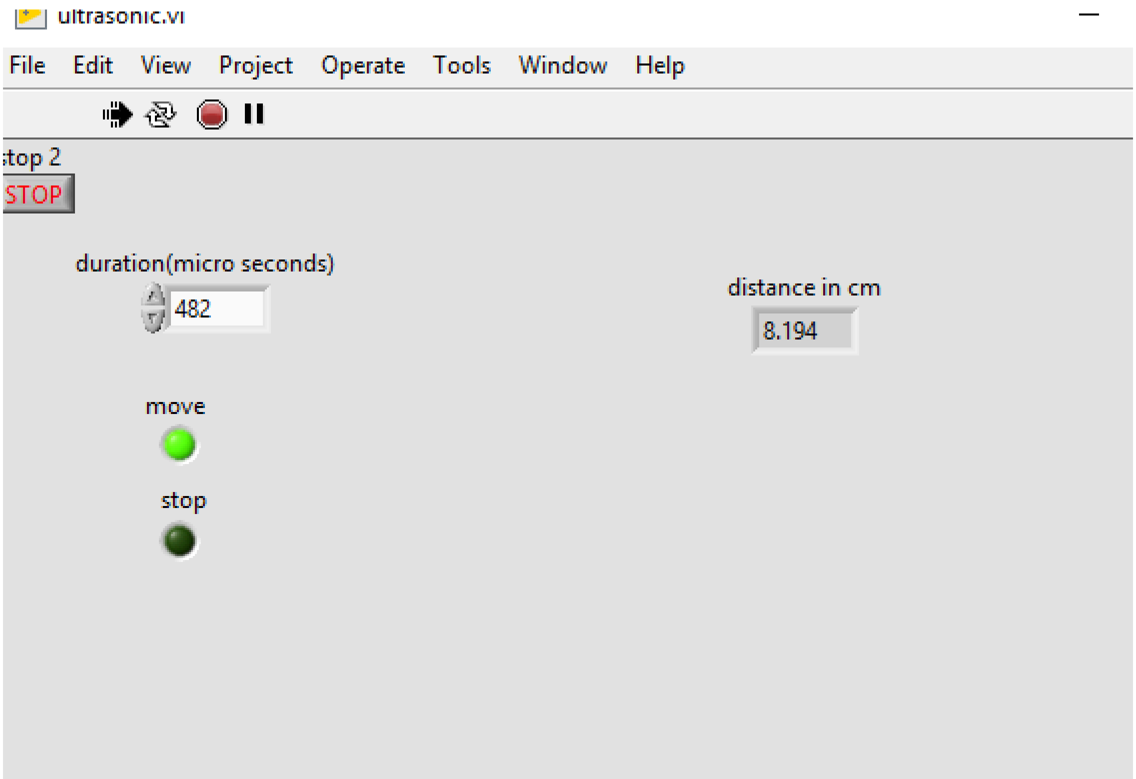


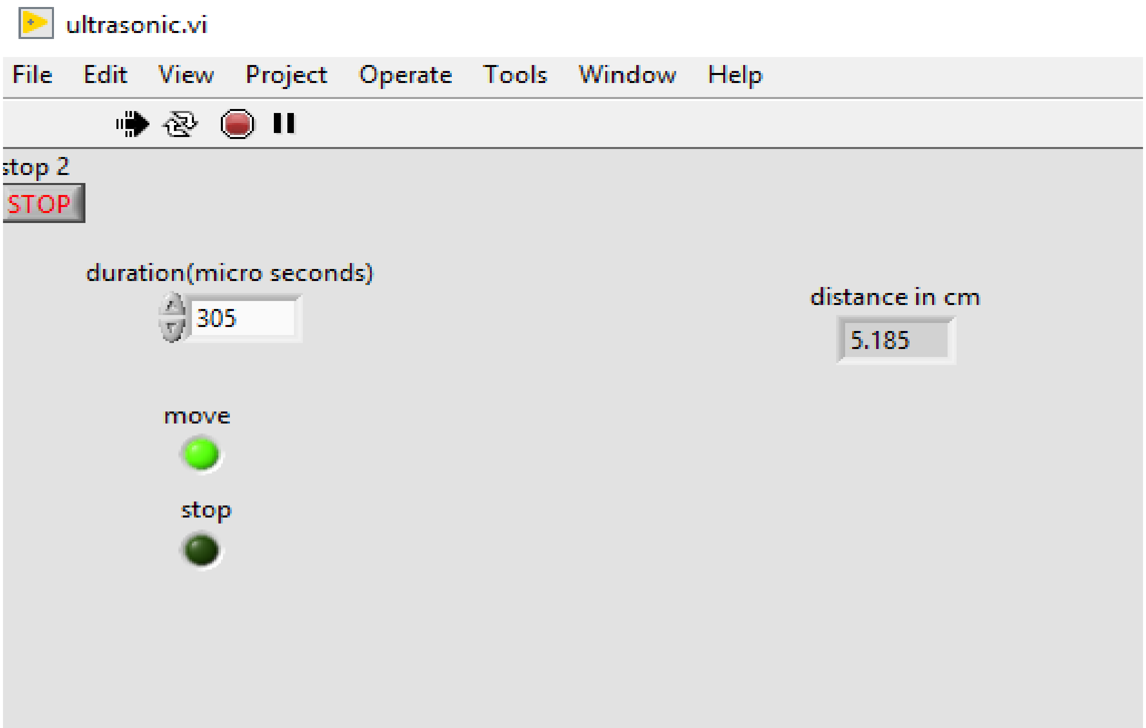
Motor Driver



Obstacle Avoidance

A system equipped with ultrasonic sensors that detect the obstacle so that the on board processor can instruct the driving motors to change the direction by giving appropriate pulse width modulated values.


ultrasonic.vi
File Edit View Project Operate Tools Window Help
stop 2
STOP
duration(micro seconds)
482
distance in cm
8.194
move
stop


ultrasonic.vi
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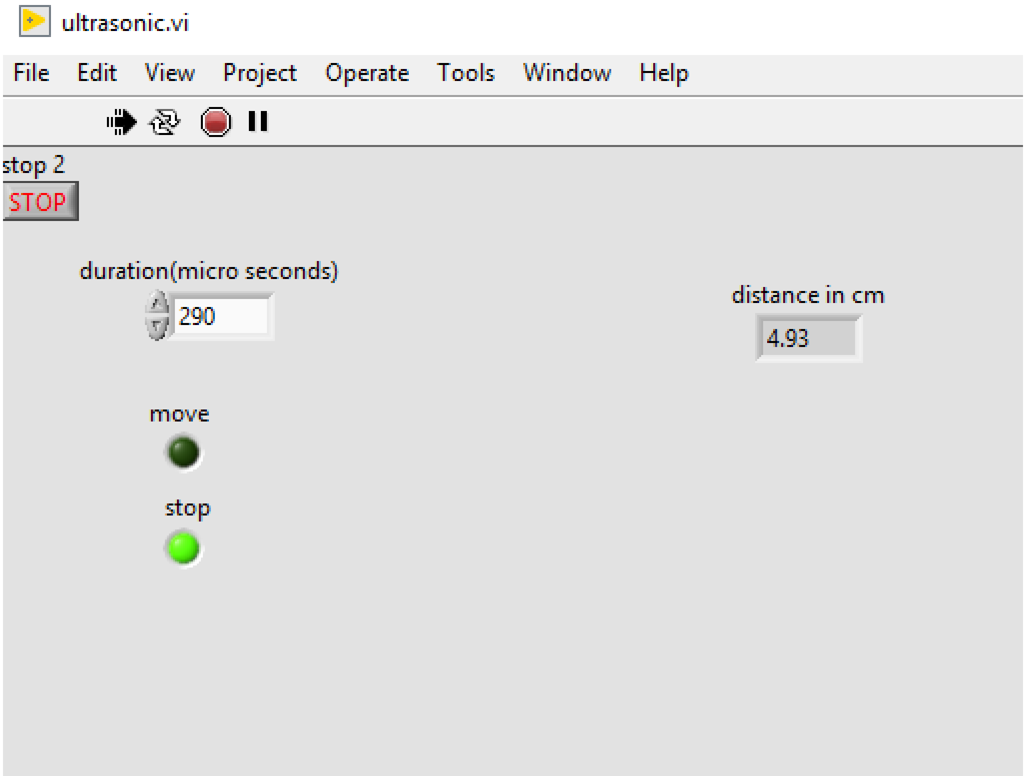
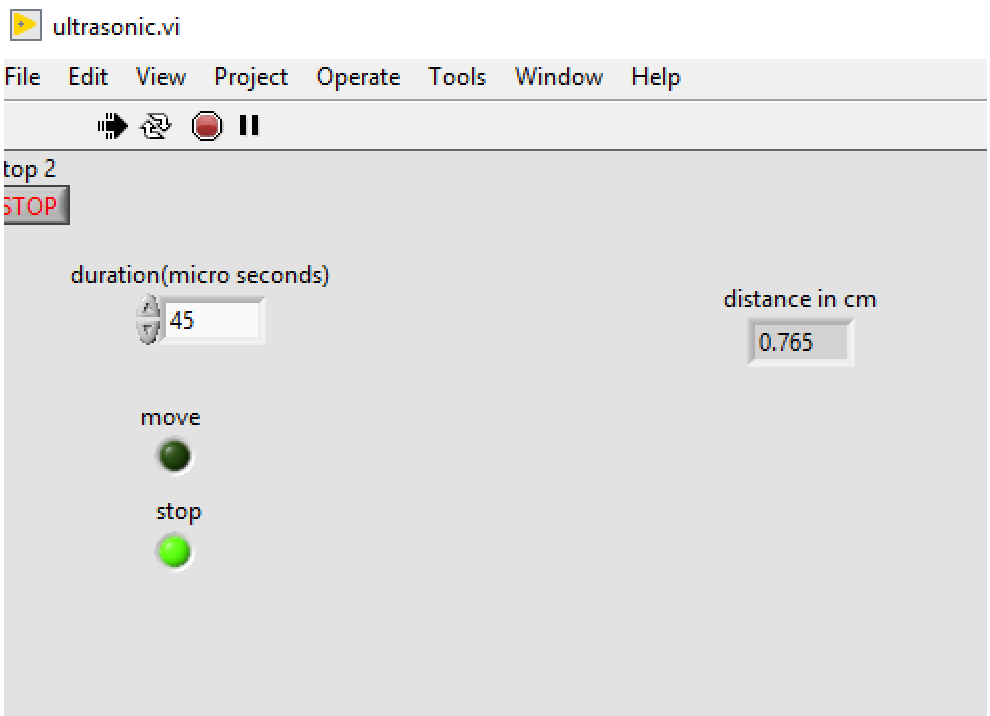
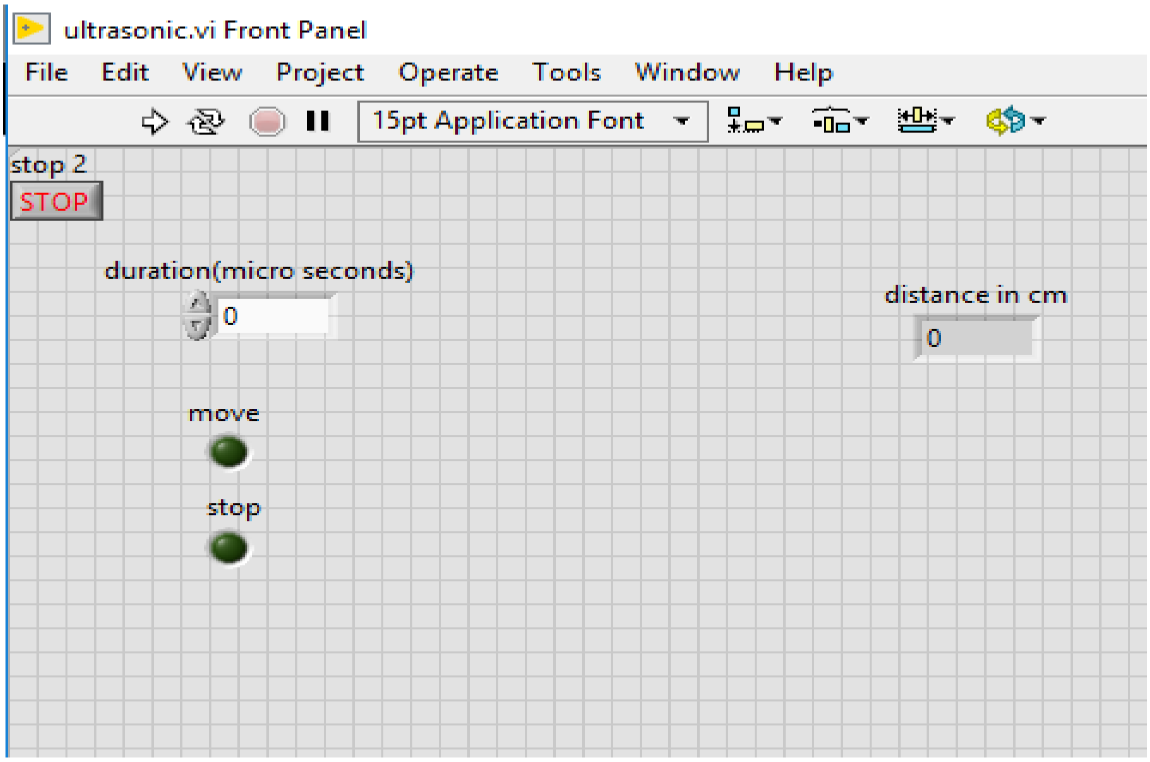
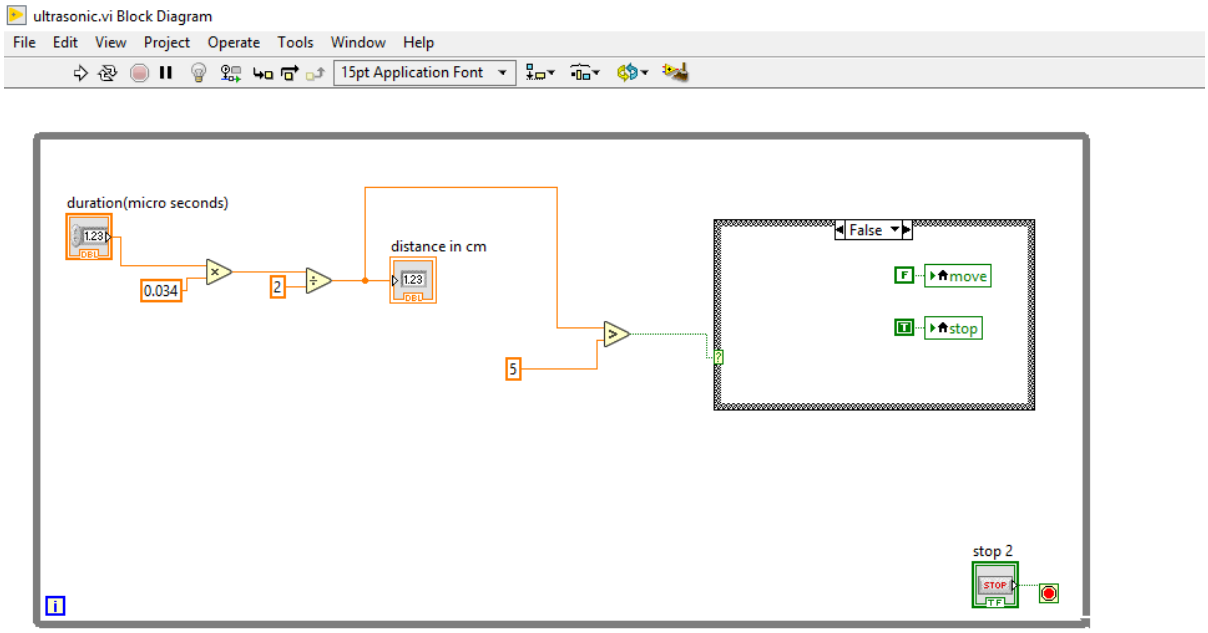
stop 2
STOP
duration(micro seconds)
305
distance in cm
5.185
move
stop

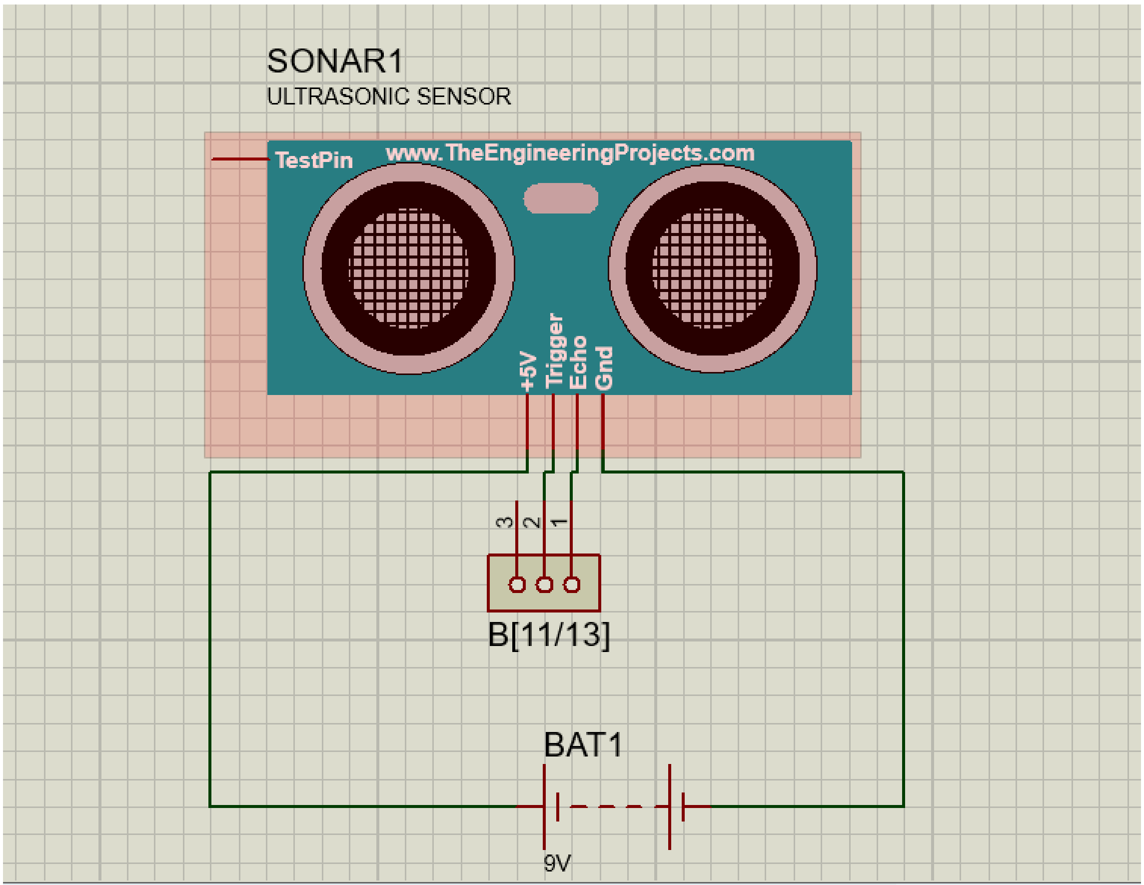

ultrasonic.vi
File Edit View Project Operate Tools Window Help
stop 2
STOP
duration(micro seconds)
290
distance in cm
4.93
move
stop


ultrasonic.vi
File Edit View Project Operate Tools Window Help
top 2
STOP
duration(micro seconds)
45
distance in cm
0.765
move
stop


ultrasonic.vi Front Panel
File Edit View Project Operate Tools Window Help
15pt Application Font
stop 2
STOP
duration(micro seconds)
0
distance in cm
0
move
stop

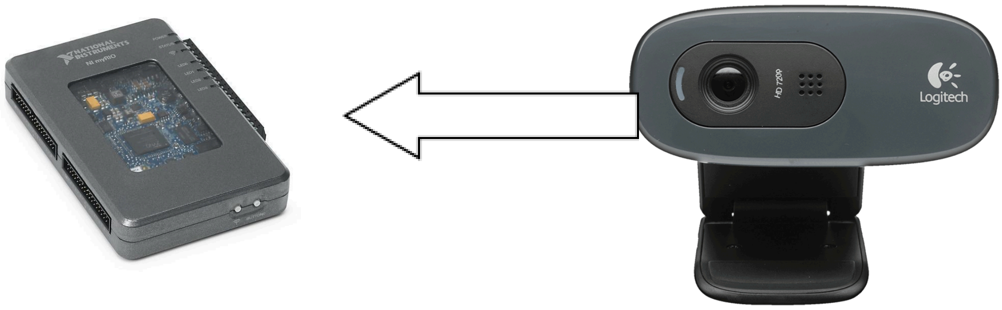

ultrasonic.vi Block Diagram
File Edit View Project Operate Tools Window Help
15pt Application Font
duration(micro seconds)
0.034
2
distance in cm
5
False
move
stop
stop 2

Ultra Sonic Sensor

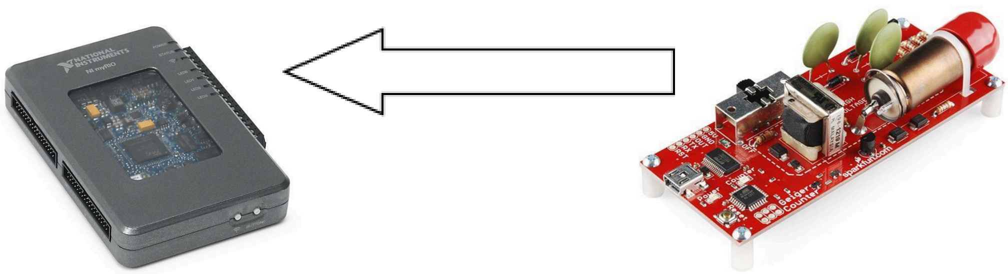


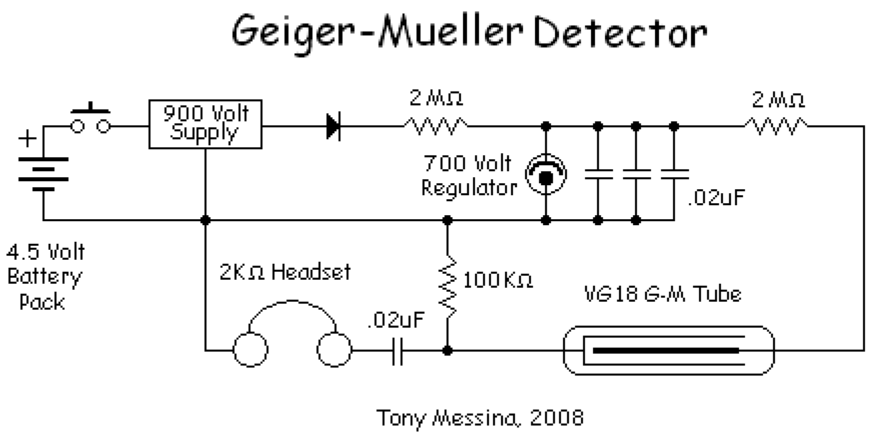
Surveillance and radiation Monitoring System:

Consists of the raw input from the radiation measuring tool such as GM counter and processing is done using LabVIEW along with mapping of the contour of the region accordingly.

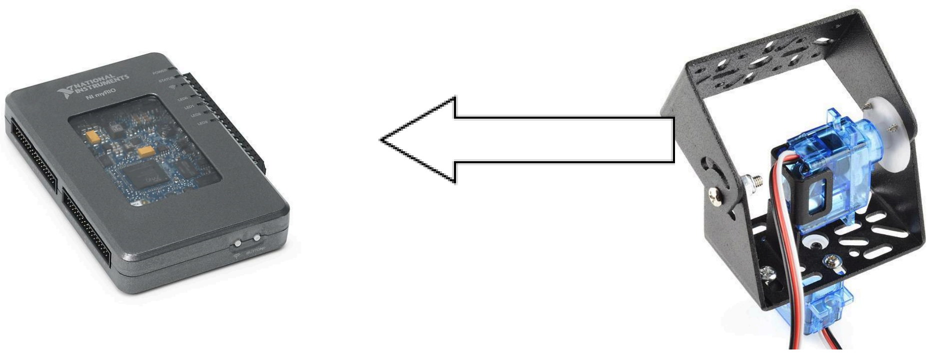


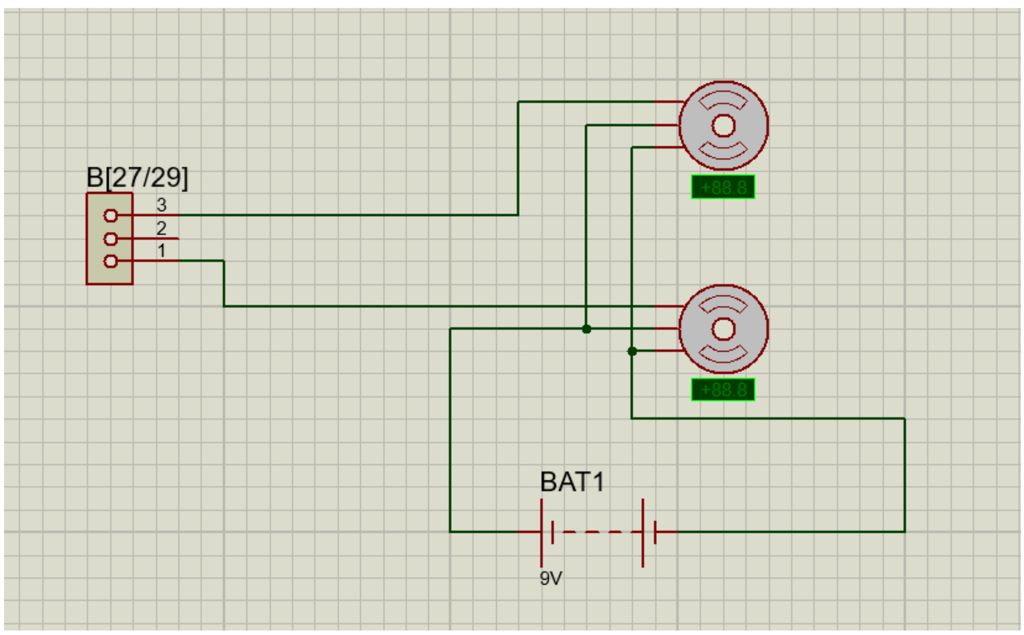
GM Counter




Geiger-Mueller Detector
900 Volt Supply
2 MΩ
2 MΩ
700 Volt Regulator
.02uF
4.5 Volt Battery Pack
2KΩ Headset
100KΩ
.02uF
VG18 G-M Tube
Tony Messina, 2008

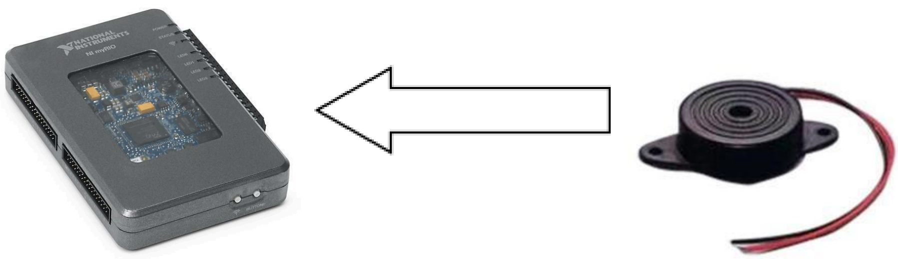
Servo Motor




B[27/29]
3
2
1
BAT1
9V

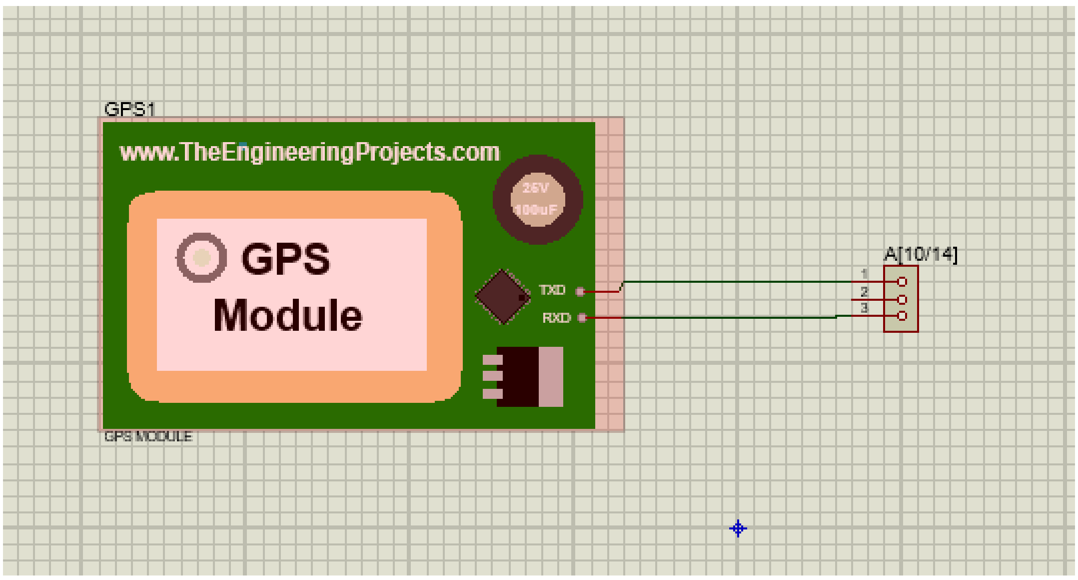
Alarm System

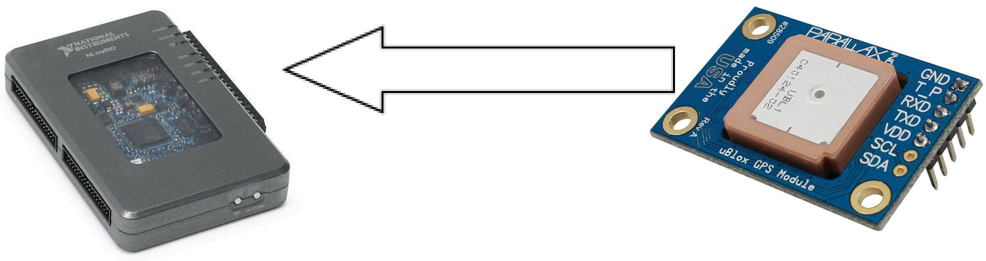
Comprising of the radioactive data from the GM counter, if the threshold is crossed a trigger is given to the piezoelectric buzzer and a red indicative light gets switched on which alerts the personnel inside the radioactive field.



Global Positioning System (GPS):-

A system which helps locate the location using radio navigation and satellite communication giving the exact latitude and longitude of the requested location.





PowerSystem:-

Lithium polymer battery is used as a primary source for the operation of the robot along with some low level converters and battery eliminating circuit (BEC) for protecting essential parts from over voltage.

Bill Of Materials

Components	Quantity	Price(Rs.)
IR Sensor	2	340
Ultrasonic Sensor	1	225
Motor Driver	1	190
Servo Motor	2(9gm)	796
DC Motor	2	660
myRio	1	34,389
USB Camera	1	999
GM Counter	1	17000
Wires	(as per requirement)	
Balancing Wheel	1	100
Piezo Buzzer	1	200
GPS Module	1	2100

Project Timeline

May 2017: Selecting the topic , preparation of abstract

June 2017: Online training by NI

July 2017: Finalizing various subsystems, taking a survey to test the waters.

Submission of Project Report

Viva of each member.

August 2017 : Individual system coding will be completed.

September 2017 : Integration of software system with hardware - MyRio

Final testing with all the systems installed.

October2017 : Final Demonstration

Applications

Applications of Robot:

- Detecting and saving people from nuclear meltdown areas
- As nuclear radiation detectors for Nuclear Power Industries
- Mining (undiscovered radioactive sites , for testing rocks and minerals for radioactivity)
- Laboratories and research departments
- Industrial Hygiene
- Diversified survey equipment for Oil and gas
- Radiology
- Environment monitoring systems

Future Prospects

Perhaps the most important source of energy for India in the coming decades is nuclear power, given its huge potential for growth, emission-free nature and consistent nature of production. Given that, developing working conditions for workers in such plants is inevitable and this project could be an affordable but significant step towards it. The GM counter could get the real time readings of radiation levels and the robot could be triggered accordingly.

This surveillance system comes at a very affordable price and with least possible maintenance. All you need to worry about is the power source which is not a big concern here as it draws very little current. It's basically a onetime investment.

With improvisation many more prospects of the project would open, the financial constraint compelled us to limit ourselves with this, e.g. we were thinking of using thermal camera instead of using normal camera, thermal camera would have given us an option to read heat signature which could have spotted exactly where the radiations level are high. There are more examples of it. In addition to this the very same concept could be used with other counters or sensors in other industries as well, e.g. instead of GM counter if we use oxygen sensor the very same model could be used in coal mines or hospital with parameters set accordingly.

References

References discussed in Literature Review:

1. Etsurou Igarashi, Katushiko Sato “Hierarchical Autonomous Mobile Control systems of a Patrol Robot for Nuclear Power Plants” , Robotics and Automation, 1995. Proceedings., 1995 IEEE International Conference on 06 August 2002.

2. Sawatsakom Chaiyasoonthom ,Nimit Hongyim, and Somsak Mitatha,” Building Automatic Packet Report System to report position and radiation data for autonomous robot in the disaster area” , 15th International Conference on Control, Automation and Systems (ICCAS 2015), Oct. 13-16, 2015 in BEXCO, Busan, Korea.

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4. R. J. Nemzek, J. S. Dreicer and D. C. Torney, "Distributed sensor networks for detection of mobile radioactive sources," 2003 IEEE Nuclear Science Symposium. Conference Record (IEEE Cat. No.03CH37515), 2003, pp. 1463-1467 Vol.3.

5. D. L. Stephens and A. J. Peurrung, "Detection of moving radioactive sources using sensor networks," in IEEE Transactions on Nuclear Science, vol. 51, no. 5, pp. 2273-2278, Oct. 2004.

6. S. M. Brennan, A. M. Mielke, D. C. Torney and A. B. Maccabe, "Radiation detection with distributed sensor networks," in Computer, vol. 37, no. 8, pp. 57-59, Aug. 2004.

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User Guide and its Specifications NI-MyRio – 1900

Internet reference:

www.ni.com

www.forums.ni.com